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ABSTRACT

Deductive reasoning problems were presented to 72 public elementary school students, half of whom were identified as gifted (mean age of 9.6 years) and half of whom were regular education students (mean age of 9.3 years). They were used to test an hypothesis that gifted children who score significantly higher than average on standardized achievement tests and who received logical reasoning training in an expanded school curriculum should not be affected by problem type or the sequence in which fantasy, congruent, and incongruent problems are presented to them, i.e., these children should evidence content free formal-logical reasoning. Results indicated that overall, older subjects performed better on this task than 4- and 5-year-olds in an earlier experiment, suggesting improvement in syllogistic reasoning with age. While there was no effect of sequence condition on the gifted children, it had a significant effect on the control group. The only condition in which these subjects could reason deductively with the incongruent material was when the fantasy problems were presented first. In addition while the gifted children consistently used more theoretical justifications for their answers, the control subjects offered more of a variety of justifications. (VW)

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Deductive Reasoning Style in Gifted Children

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Studies investigating the development of deductive reasoning have been equivocal as to the youngest age of formal logical competence and whether the performance on logical tasks is or is not a function of underlying systems of logical thought. Such debate has led to three competing theoretical models- one that supports a cognitive competence position , one that emphasizes the role of context variables in mediating task performance, and a model proposing an interaction between competence and performance moderators.

According to the theoretical framework of Piaget, deductive reasoning is defined as making inferences from premises to a conclusion that must be held true independently from the empirical truth of the premises. This ability, according to Piaget, develops when the underlying cognitive structure of transitive inferencing has been constructed by the child. This cognitive competence is not expected until late childhood. In his study of deductive reasoning using transitive inference tasks, Piaget failed to find logical competence in children until late concrete operations.

However, since that time, some studies have shown that when task requirements are minimized and materials used are familiar to the subjects, even very young children exhibit correct deductive reasoning. In a paper specifically investigating deductive syllogistic reasoning, Hawkins, Pea, Glick & Scribner (1984) analyzed the affect of varying problem content and sequence of problem presentation in 4 and 5 year old children. The three different types of problems used were fantasy problems in which premises described mythical creatures

foreign to real world knowledge; congruent problems in which premises were compatible with practical knowledge and incongruent problems in which premises were in contradiction to real world knowledge. The sequence in which fantasy, congruent and incongruent problems were given was systematically varied. Analyses of the affects of these manipulations on correct responses and justifications for responses showed that 4 and 5 year old children could perform deductive reasoning and that both the empirical truth-value of the problem content and the task organization as determined by the sequence in which fantasy, congruent and incongruent problems were given affected the use of that skill. When children received congruent or incongruent problems first, they used empirically based reasoning but when given fantasy problems first children could use the information in the premises in deductively correct ways.

Such performance differences have led Griggs (1983), Mandler (1983) and others to argue that logical reasoning is mediated by semantic or other contextual variables and that cognitive operations play little or no determining role in children's success or failure. However, such interpretations mask the distinction between reasoning based on the formal relations of elements in the premises and making inferences to conclusions based on real world knowledge.

A third model, the competence-moderator-performance model of Overton (1985, Overton & Newman, 1982), suggests that underlying cognitive competencies are a necessary but not sufficient condition for logical reasoning performance. Overton and his colleagues argue

for a distinction between underlying formal logical competence, that a subject may or may not possess, and other factors that can a) yield both false positive and negative judgements of the psychological reality of competence and b) operate to influence the actual use of competence once it is acquired. Failure to make this distinction may be what leads to findings suggesting young children reason according to the rules of logic which underplay the role of cognitive operational competencies. Some factors that influence the use of underlying competence according to the competence-moderator-performance model are the semantic content of the problems, task interpretation and cognitive style.

In a recent paper, Overton & Ward, Black, Noveck, & O'Brien (1987) report a developmental difference in the mediating affect of problem content. Their data show no differences between logical reasoning performance on a modified Wason selection task of conditional reasoning with abstract or familiar content material in young children or in older subjects with 4th and 6th grade children doing consistently poorly and 10th and 12th graders doing consistently well but a significantly better performance in 8th graders with familiar as opposed to abstract content. This suggests that using materials in logical tasks that are familiar can not be a sufficient condition of logical reasoning.

The research presented here investigates whether a similar developmental effect will be found with the Hawkins, et al problem content and sequence manipulation in syllogistic reasoning. There are also two types of subjects participating in this study- gifted and

matched controls. It is hypothesized that the gifted children who score significantly higher than average on standardized achievement tests and who receive logical reasoning training in an expanded school curriculum should not be affected by problem type or the sequence in which fantasy, congruent and incongruent problems are presented to them. That is, these children should evidence content free formal-logical reasoning. This hypothesis is supported indirectly by findings that children who do well on standardized tests have a reflective cognitive style- a variable shown by Overton, Byrnes, and O'Brien (1985) to be related to successful reasoning performance.

Our predictions are that 1) overall the older children used in this study should not be as affected by content and sequence as the Hawkins et al subjects although their performance should be best with fantasy and congruent material; 2) overall they should offer more theoretical justifications for their responses than the younger children; and 3) the gifted children's success with the three different problem types and the justifications they give for their responses should not be affected by the sequence in which the problems are given. In other words the task organization should not influence their reasoning style.

Subjects in the gifted group were students who had been selected to participate in an Expanded Programs Opportunities curriculum for gifted children in two public elementary schools. These students are identified by the school staff. Criteria used in the selection are an I.Q. score higher than 130 , scoring in the 98th percentile on the Stanford Achievement Test measuring math, reading, and language

achievement, a high Renzulli-Hartmann rating for superior students in learning, motivation, creativity and leadership; and a high rating for potential success in the gifted program by the child's classroom teacher. Students in the gifted program are pulled from their classrooms two to three hours per week for the expanded opportunities curriculum. During this time they receive training in logical reasoning , divergent thinking and creativity.

Method

Subjects. 72 subjects participated in this study and were recruited from suburban public elementary schools. Half of the subjects were gifted students as measured by the above critieria and the other half were students matched for age and grade who were randomly selected by classroom teachers. The mean age for the gifted group was 9.6 years and the mean age for the control group was 9.3 years.

Subjects in each group were randomly assigned to one of three conditions: FIC (fantasy problem content first, then incongruent, then congruent); IFC; or CIF. Examples of the deductive reasoning problems of each type can be found in Appendix A.

Procedure. The children were seen individually on one occassion by one of two experimenters. They were each given 24 deductive reasoning problems in the order determined by their experimental condition. The order of presentation of the eight problems in each of the three content types (fantasy, congruent and incongruent) was randomized. There were an equal number of reasoning problems of universal form, particular form, and problems representing

action/functional relationships. Half the problems required an affirmative correct response and half required a negative correct response. Children were asked to give a yes/no response to the conclusion posed as a question (for example "Is Maca a geeter?") and to give a justification for their answer. All responses were voice recorded.

Results

The mean number of correct responses to the deductive reasoning problems can be found in Table 1 presented by group, sequence, and problem type. An analysis of correct responses revealed no overall effect of group ($F(1, 218) = .3579$). Separate 3x3 sequence by problem type analyses of variance were calculated on the data for each group. The anova for the gifted group revealed a significant main effect for problem type ($F(2, 99) = 19.8$; p .001) but no effect for sequence and no interaction ($F(2, 99) = .15$ and $F(4, 99) = .004$; respectively). Tukey's post hoc tests showed that performance with fantasy and congruent content was significantly better than performance with incongruent material in this group (p .05). Performance with fantasy and congruent content problems was not significantly different from each other in the gifted group.

The analysis for the control group revealed main effects for sequence and problem type and a significant interaction ($F(2,99) = 7.59$, p .01; $F(2,99) = 67.06$, p .001; $F(4,99) = 2.85$, p .05; respectively). Tukey's post hoc tests showed that control group

subjects in the FIC sequence condition correctly answered signficantly more incongruent problems than subjects in the other two sequence conditions. There were no significant differences between sequence conditions for incongruent problems for the IFC versus CIF condition and the sequence conditions did not produce significantly different performance with fantasy or congruent problems (p .05).

Post hoc analyses of the main effect for sequence revealed signficantly better performance in the FIC condition than in the other two which were not different from one another. Post hoc analyses of the main effect for problem content revealed that subjects performed signficantly better with fantasy and congruent problem material than with the incongruent material (p .05).

Childrens' justifications for their answers were coded into five categories from Hawkins, et al. Theses were 1: Theoretical justifications where the child made reference to the premises stated in the problem; 2: Empirical justifications where children called upon their real world knowledge to support their responses; 3: Authority justifications where a child made reference to the opinion of an authority figure to support their answer (for example- "My mother told me") and 5: all Other justifications including " I don't know" and uninterpretable responses. The percentage of each justification type given by group and sequence is presented in Table 2 .

Subjects in the gifted group used significantly more theoretical justifications in both the FIC and CIF conditions but gave theoretical and empirical justifications equally often in the IFC condition.

Subjects in the control group gave significantly more theoretical justifications in the FIC condition; more empirical justifications in the IFC condition; and used theoretical and empirical justifications equally often in the CIF condition. Therefore the pattern for justification use by gifted and control subjects did not differ significantly in both the FIC and CIF sequence conditions. However, when given the incongruent content problems first, control subjects tended to give more wrong answers and empirical justifications for those answers while gifted children answered those incongruent problems correctly more often and maintained a theoretical or formal logical approach to all problems.

Discussion

The results of this study indicate that overall, older subjects perform better on this task than 4 and 5 year olds suggesting improvement in syllogistic reasoning with age. However there were interesting interactive effects found between group (gifted versus control) and the effect that problem content and sequence had on the children's responses. There was no effect of sequence condition on the gifted children- receiving fantasy, congruent or incongruent problems first did not effect their percentage of correct responses. A finding that supports one of our predictions. The gifted children had problems with the incongruent material but their performance in this problem condition far exceeded that of the control children. Furthermore, children in the gifted group consistently used more

theoretical justifications for their answers.

The sequence condition the subjects were in significantly affected performance in the control group. In fact, the only condition in which these subjects could reason deductively with the incongruent material was in the FIC sequence condition. It may be that having the fantasy problems first which necessitate a theoretical rather than an empirical reasoning approach initiated a style of reasoning which these children maintained across the other two problem types. This is consistent with one of the Hawkins, et al findings with 4- and 5-year olds. Furthermore, control subjects offered more of a variety of justifications for their answers with theoretical and empirical justifications being offered equally often only in one sequence condition- the CIF condition.

It is difficult to explain these results with either a competence model (because of the problem content effect in the gifted children) or a contextual model because of the differing impact of the sequence manipulation on the two groups of subjects- the gifted children were not affected by the sequence of problem types. It may seem that the competence-moderator-performance model wins by default. However, the moderator in this case- sequence of presentation, only affected one group of subjects in one sequence condition. It only affected the control subjects in the FIC condition begging questions about the predictive power of such an interactive model.

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Appendix A

Examples of Stimulus Materials

Fantasy Problems

Affirmative	Negative
Every nerple likes grapes.	Tunips do not know how to laugh.
Oscar is a nerple.	Marvin is a tunip.
Does Oscar like grapes?	Does Marvin know how to laugh?

Congruent Problems

Affirmative	Negative
All kangaroos can hop.	People that smile are happy.
Animals that hop live on land.	Julie is not smiling.
Do kangaroos live on land?	Is Julie happy?

Incongruent Problems

Affirmative	Negative
Every alligator has teeth.	Nothing made of rubber bounces.
All animals with teeth chew gum.	A superball is made of rubber.
Do alligators chew gum?	Does a superball bounce?

Table 1

Mean correct responses by Group, Sequence and Problem Type.

	Problem Type			
	Fantasy	Incongruent	Congruent	
Gifted				
FIC	7.50	3.50	8.00	(6.30)
IFC	6.00	2.57	6.86	(5.14)
CIF	6.57	2.71	7.43	(5.57)
	(6.69)	(2.93)	(6.87)	
Control				
FIC	7.63	4.13	7.75	(6.50)
IFC	5.50	.88	7.25	(4.54)
CIF	7.50	.66	8.00	(5.39)
	(6.88)	(1.89)	(7.66)	

Table 2

Percentage of Justification Type by Group and Sequence.

	Theoretical 1	Empirical 2	Restatement 3	Authority 4	Other 5
Gifted					
FIC	74.5	24.5			1
IFC	54.2	45.8			
CIF	58.9	41.2			
	(62.5)	(37.1)			(.4)
Control					
FIC	70.3	27.1		.5	2.1
IFC	37.5	55.2	.5		6.8
CIF	50.0	47.2			2.8
	(52.6)	(43.0)	(.2)	(.2)	(4.0